REMARKS/ARGUMENTS

Reconsideration of this application is requested. Claims 1, 8-22, 38 and 39 will be pending in the application subsequent to entry of this Amendment. All of the examined claims are directed to elected subject matter.

Claim Amendments/New Claim

The claims have been amended in order to more particularly point out and distinctly claim that which applicants regard as their invention and direct them to preferred aspects of the disclosure.

An error has been noted in claims 1 and 38 which requires correction, namely "$Hg_{1-x}Cd_xTe$ where x is $0 \leq x \leq 1$" in the preamble should be restricted to "$Hg_{1-x}Cd_xTe$ where x is $0<x<1$". Amended claim 1 specifies "$0<x<1$" so that the method only covers the ternary CMT compound. The application clearly describes the growth of a CMT layer comprising mercury by an interdiffusion process (see page 17, line 17 to pay 21, line 14).

Dependent claim 6 was inadvertently cancelled when the RCE was filed. This claim is added back into the application as new claim 39 with the following further clarifying amendment:

> 39. A method as claimed in claim 1 wherein the silicon substrate orientation is (001) mis-aligned between 1° and 10° towards the [111] direction, and the wherein the buffer layer sets the substrate orientation to (001).

Also step (b) in claim 38 is amended to read:

> "b) growing one or more buffer layers selected from zinc telluride, cadmium telluride and cadmium zinc telluride on said substrate by molecular beam epitaxy to form a buffered silicon substrate and to set the substrate orientation to (001), and"

Basis for the amendment to claims 38 and 39 can be found at page 6, lines 16-17, where it is explained that the buffers layers set the correct orientation for MOVPE growth, and at page 16, lines 8-9 where it is explained that a buffer layer of ZnTe is grown to set the substrate orientation to (001).

The invention

The present invention is a method of fabricating an infrared device comprising a cadmium mercury telluride, $Hg_{1-x}Cd_xTe$ where x is $0<x<1$, device layer, the method comprising the steps of:

(a) taking a crystalline silicon substrate,

(b) growing one or more buffer layers chosen from zinc telluride, cadmium telluride and cadmium zinc telluride on said substrate by molecular beam epitaxy to form a buffered silicon substrate and to set the substrate orientation to (001), and

(c) growing at least one device layer of cadmium mercury telluride on the buffered silicon substrate by metal-organic vapour phase epitaxy.

The invention requires firstly, that the substrate is silicon; secondly, that the device layer is $Hg_{1-x}Cd_xTe$ where x is $0<x<1$; and thirdly, that the buffered substrate comprises one or more layers chosen from zinc telluride, cadmium telluride and cadmium zinc telluride. Furthermore, and importantly, the buffered silicon substrate is formed by molecular beam epitaxy (MBE) and a device layer of cadmium mercury telluride (CMT) is then grown on the buffered substrate by metal-organic vapor phase epitaxy (MOVPE). In other words, MBE is used to grow the buffered substrate and MOVPE is used to grow the CMT device layer.

Claim 1 recites a very specific combination of method features, which features are advantageous for producing CMT-based infrared devices. As discussed in the original PCT application (c.f. page 6, lines 16-22) the buffer layers set the correct orientation for MOVPE growth and prevent chemical contamination of the cadmium mercury telluride by species in the substrate. The choice of buffer layer depends on the substrate being used and the inventors have found that, in the particular case of growing a cadmium mercury telluride device layer on silicon by metal-organic vapor phase epitaxy, one or more buffer layers chosen from zinc telluride, cadmium telluride and cadmium zinc telluride is suitable. The other key feature of the invention is the combination of two growth techniques, namely MBE for the buffer layer and MOVPE for the device layer. The inventors have found that mixing those particular two techniques – despite adding to the complexity of the method - can provide a reliable and controllable process that has produced excellent devices (c.f. page 5, lines 7-11).

In a particularly preferred embodiment of the invention (as defined by dependent claim 39 and independent claim 38) the silicon substrate orientation is (001) mis-aligned between 1° and 10° towards the [111] direction. CMT grown on buffer layers on silicon at the {100} orientation has a tendency to form domains and hillock defects. However, the inventors have found that a mis-orientation from (001) of a few degrees towards [111] can eliminate domains and therefore reduce defects (c.f. page 14, lines 17-21.)

Response to Claim rejections under 35 USC § 103

Counsel observes that the Official Action cites for the first time eight new references and applies many of them to the claims now examined.

The Examiner has rejected independent claims 1 and 38 under 35 USC § 103(a) as obvious over US 2003/0102432 (Boieriu et al) in view of US 4,804,638 (Hoke et al) both newly cited.

With regard to claim 1, it is alleged that Boieriu discloses all the limitations of claim 1 except for growing the CMT by MOCVD, whereas Hoke discloses a method of fabricating a HgCdTe device layer using MOCVD. Therefore, it would have been obvious to the skilled person to modify the deposition method of Boieriu and incorporate metalorganic chemical vapour deposition as an alternative CVD deposition method.

To this applicants respond as follows:

(i) Boieriu et al teaches a method of fabricating an infrared sensing device including a multi-layer II-VI semiconductor material on a readout circuit fabricated on a silicon substrate having an orientation 1° tilted from the (100) direction. In Boieriu, the crystalline buffer layer is grown by molecular beam epitaxy (MBE) and - as the examiner notes – growth of the CMT device layer on the buffer layer is also achieved by MBE. Accordingly, applicants agree with the Examiner's conclusion that Boieriu does not disclose step (c) of growing at least one device layer of CMT layer on the buffered silicon substrate by metal-organic vapor phase epitaxy (MOVPE).

(ii) The Examiner argues that it would be obvious to modify the deposition method of Boieriu to incorporate MOCVD as taught by Hoke. However, it is respectfully noted that while it is certainly true that MOVPE is a well known method of growing epitaxial layers, it is not necessarily the case that MOVPE is an obvious alternative to MBE. Both MBE and MOVPE are

methods for epitaxial growth of materials but, for both methods, the starting conditions and conditions of growth are important and will affect the properties of the material grown. The properties of epitaxial layers grown by MBE and MOVPE can vary significantly, and ensuring that acceptable quality material is grown involves a good understanding of the different principles of operation of the two different methods, and careful control of the initial conditions. Even then, it may be that a material system may be grown by MBE, for instance, that cannot be grown to an acceptable level by MOVPE or vice versa. MOVPE uses metal-organic precursors and hence introduces additional elements into the growth process not present in MBE. The reaction of such elements to the materials present in the growth surface will affect the growth and must be considered and catered for.

(iii) Thus, while MBE and MOVPE are alternative techniques for growth of epitaxial layers it is certainly not the case that one skilled in the art would assume that a step of growing an epitaxial layer by MBE could obviously be replaced by an MOVPE growth process.

(iv) At no point in its disclosure does Boieriu contemplate an alternative method for growing the buffer layer or CMT device layer and – indeed – it improves upon the known growth technique of HgCdTe on Si using two separate MBE systems (c.f. paragraph [0064]) by proposing an alternative system which conducts all-MBE growth in one chamber only (c.f. paragraph [0065]). It is submitted, therefore, that Boieriu itself teaches away[1] from adopting an alternative growth process for the CMT device layer, which would necessarily require two growth chambers.

(v) With regard to Hoke, this document discloses that “several problems are encountered in the art of growing mercury cadmium telluride epitaxial layers by the MOCVD technique”, one particular problem being compositional uniformity of the deposited epitaxial layers (c.f. column 1, lines 34-38) and the document goes on to address such problems by the use

[1] An important consideration in determining obviousness is “teaching away” from the claimed invention by the prior art. *In re Dow Chemical Co.*, 837 F.2d 469, 473 (Fed. Cir. 1988. A reference teaches away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant. A reference will teach away if it suggests that the line of development flowing from the reference’s disclosure is unlikely to be productive of the result sought by the applicant. *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994); *see also KSR*, 127 S. Ct. at 1739–40 (2007) explaining that when the prior art teaches away from a combination, that combination is more likely to be nonobvious.

of particular MOCVD precursors. Hence, Hoke itself indicates that the selection of MOCVD is not simply a matter of routine design choice.

(vi) In summary, despite the fact the MOVPE is a well known epitaxial growth process (as exemplified by Hoke) applicants submit that Boieru teaches away from replacing the MBE growth step with MOVPE. Moreover, there is no suggestion in Hoke that MOVPE might be used in combination with MBE for the fabrication of CMT device layers of Si and indeed, Hoke supports applicants' assertion above that the use of MOVPE as an alternative technique is not necessarily a simple modification which would have been contemplated by the skilled person.

With regard to claim 38, this claim contains all the limitations of claim 1 and hence, is patentable for at least the reasons outlined above.

Additionally, the Examiner refers to paragraphs [0069] to [0073] of Boieriu, and represents (incorrectly) that Boieriu discloses that buffer layer growth is performed on Si(001) misaligned between 1° and 10° towards the [111] direction. This is not correct, however. Boieriu merely discloses Si(001) tilted around 1° off axis, and provides no teaching as to the direction of mis-alignment. In the present invention, it has been found that growing the buffer layers on Si(001) misaligned between 1° and 10° towards the [111] direction enables the substrate orientation (and hence, the final CMT layer) to be set to (001). In contrast, Boieriu results in the growth of CdTe(111)B. Accordingly, the additional subject matter of claim 38 is non-obvious over Boieriu.

In view of the above, applicants submit that Boieriu et al in combination with Hoke et al does not suggest the particular combination of features of claim 1 and claim 38. For similar reasons, particular patentability is alleged for new dependent claim 39.

The remaining rejections under 35 USC § 103 have been raised in respect of dependent claims 8-22 only; it is submitted that those claims are patentable by virtue of their respective dependencies; see MPEP §2143.03 and *In re Fine*, 5 USPQ2d 1596 (Fed. Cir. 1988).

All outstanding issues have been addressed and this application is in condition for allowance. Should any minor issues remain outstanding, the Examiner should contact the undersigned at the telephone number listed below so they can be resolved expeditiously without need of a further written action.

The Commissioner is hereby authorized to charge any deficiency, or credit any overpayment, in the fee(s) filed, or asserted to be filed, or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our Deposit Account No. 14-1140.

Respectfully submitted,

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